Getting the right picture: Imaging options in urology:

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If you are getting help from a urologist, you'll likely be referred for medical imaging. These images will allow your doctor to confirm your diagnosis and guide your management or follow-up. In this chapter, I'll summarize the types of medical imaging you may need during your care. You should contact your urologist for any specific questions about your personal imaging needs.

In most cases, every effort will be made to make sure the radiation dose you receive is as low as possible. The good news is that over time the amount of radiation exposure you will need to get high quality images will decrease as advances in technology increase. This will minimize your long-term risks.

The risk of medical imaging must always be weighed against the potential benefit of diagnosing and treating a particular condition. Table 1 gives you a quick list of which imaging tools expose you to the risks of radiation.

Table 1. Different types of imaging and exposure to radiation risks

Type of imaging tool	Would it expose me to radiation?
Plain radiography	Yes
Computed tomography	Yes
Nuclear imaging	Yes
Ultrasound	No long-term consequences
Magnetic resonance imaging	No long-term consequences

Risks associated with medical imaging can be divided into those related to radiation and those related to the use of contrast materials. If you have concerns about the risks associated with medical imaging, discuss these with your urologist before getting these images done.

Radiation risk

Radiation exposure is measured in units referred to as millisieverts (mSv), named after a Swedish medical physicist who performed work on radiation exposure.

In general, without any exposure to medical imaging, the average person in North America is exposed to 1-3 mSv of radiation per year.

Table 2. Risks linked with medical imaging: Related to radiation

Plain x-rays (or plain radiography)	Has the least amount of radiation exposure Associated with the least amount of risk
Computed tomography (CT) scan (a scan that generates a 2-dimensional image)	Often requires that you be scanned 2-3 times Associated with more radiation exposure
Nuclear scanning (injection of radioactive elements to analyze blood flow)	Has the same radiation exposure as CT scans

While there is no safe dose for radiation exposure, medical personnel who receive occupational exposure to radiation are recommended to limit their exposure to under 50 mSv per year.

Radiation exposure during a KUB (or kidney, ureter, bladder, which is a plain x-ray of the abdomen typically used for patients with stones) ranges between 0.1-1 mSv which is lower than radiation exposure following a non-contrast CT scan of the abdomen which ranges from 1-10 mSv.

An enhanced CT scan of the abdomen done in 3 phases: (1) before intravenous contrast; and (2-3) two times after the injection of the contrast material. This injection carries a radiation exposure of 25-40 mSv. Contrast material is opaque to X-rays and allows your radiologist to examine the organ or tissue that it fills.

Radiation exposure to the eyes, ovaries and testicles is more significant impact than exposure to other tissues in the body. Over time as technology improves, radiation exposure from CT scans will likely be significantly reduced.

There is no safe dose of radiation exposure. Your exposure should be limited, as much as possible. You should discuss the risks, benefits and goals of any radiation-based medical imaging study with your urologist. Your doctor will discuss the harm associated with radiation and balance it with the potential benefits of diagnosis and the risks of not diagnosing your particular urologic condition.

Contrast risk

To make sure the doctor can see as much detail as possible, contrast material may be used during plain radiography, CT scanning and MRI scanning.

The contrast material used for plan radiography and CT is iodine-based, whereas the contrast for MRI is gadolinium-based. If you've had a reaction with the iodine-based contrast, you may need MRI contrast. If you have any questions or concerns about possible reactions, discuss these with your urologist or family physician.

Reactions to iodine-based contrast can range from minor to life-threatening.

You are at risk of reactions if you have:

- a past reaction to iodine-based contrast
- a history of asthma
- iodine allergy
- severe heart disease
- poor kidney function
- dehydration
- sickle cell anemia
- some rare tumours, which can affect the adrenal glands or other sites in the body, known as pheochromocytoma

Minor and severe reactions to iodine-based contrast

Minor reactions

Nausea

Vomiting

Flushing of the skin

Itching

Headache

Pain at the site of injection (typically the arm)

These reactions can be treated with over the counter antihistamine medications.

Severe reactions

Reduced blood pressure*

Spasm of the airways*

If you are taking metformin for diabetes mellitus, you may be asked to stop taking it for 48 hours after receiving the iodine contrast.

Contrast-induced nephropathy (kidney disease)‡

Impaired function of your kidneys‡

*You can treat these with steroids or with the medication over the counter antihistamine medications.

‡These reactions are rare if you have a normal kidney; if you are elderly, have chronic kidney disease, diabetes, are dehydrated, have heart failure or high blood pressure, these are potential reactions.
You may need a blood test to check your kidney function before receiving iodine-based contrast.

Minor and severe reactions to gadolinium-based contrast*

Minor reactions

Coldness, warmth or pain at the injection site

Nausea

Headache

Dizziness

Itching

Severe reactions

Nephrogenic systemic fibrosis (NSF) and occurs in patients with advanced renal dysfunction.

Involves skin thickening, itching, contraction of joints

May effect organs such as the lungs, heart and esophagus

Symptoms may progress within a few days to months of exposure and can result in death

Depending on the degree of renal dysfunction, the risk of NSF may be quite low and acceptable to obtain the information required from the MRI with contrast

*Adverse reactions after receiving gadolinium-based MRI contrast are least frequent and typically milder reactions than those of iodine based contrast for CT or plain radiography.

Types of Imaging

Types of imaging

Imaging method

Radiography or plain X-rays

Reason for using it:

- To diagnose and manage kidney stones (80% of stones are easily visible on plain x-ray)
- To allow your urologist to find calcium-based stones in your urinary tract
- To examine your lungs to see if there are underlying lung conditions that may complicate anesthesia before surgery, or to determine if there is any spread of a cancer to the lungs
- With contrast injected in the tip of the penis, to assess for urethral stricture (narrowing of the urinary passage through the penis from the bladder) or to assess any injuries to pelvis to make sure the urethra or the bladder has not been damaged

Reasons to use other imaging methods:

- If there are overlying bowel contents or stone types, such as uric acid, which is not visible on plain X-ray, other imaging tools may be needed
- If your kidney stone is hidden
- If your pain is likely due to a kidney stone, you will have a CT scan of the abdomen and pelvis
  - A plain KUB (which stands for kidneys, ureters and bladder) + a CT scan may be needed to track the movement of the stone and to guide your treatment options
- If you have a history of kidney stones and they've been seen with a KUB, you can ask for another KUB instead of a CT scan – this will reduce your exposure to radiation.

Radiography or X-rays

If your doctor is considering shock wave lithotripsy, a non-invasive treatment that would send shock waves and destroy the stones, you need to know whether the stone is visible on KUB. Plain X-ray is usually used within the lithotripsy unit to target the stone for treatment and to follow the passage of any stone fragments.

Plain radiographs may be used in addition to the injection of intravenous contrast or the injection of contrast directly into the urinary tract. Intravenous pyelograms (IVP) were once commonly used to diagnose kidney stones. IVP tests are now rarely done and have been replaced by non-contrast CT scans for diagnosing kidney stones. They are still used in some remote areas where CT scans are not available.

Retrograde pyelography involves the direct injection of radiocontrast into the urinary system. This is useful to check your urinary system for any obstruction, stones or tumours. It may be performed as an outpatient in a cystoscopy unit or while under general anesthesia as part your surgical treatment for stones. Retrograde pyelography is mostly used in patients who are being assessed or treated for urinary stones, hematuria. It is also used in patients with a history of bladder cancer to check their renal collecting system (or the reservoir within the kidneys). A loopogram is similar to retrograde pyelography. This is performed by injecting contrast into the stoma, or opening on the skin, of patients with urinary diversions. Again this is typically used to assess for any evidence of obstruction of the urinary tract.

Computed tomography (CT scan)

With a CT scan, you need to be able to lie still on an x-ray table as you move slowly through a "doughnut" or gantry. The x-ray beam is generated on one side of the gantry and detected on the other side as you move through. The end result provides your doctor with a series of images that look at the body in cross section.

Excellent detail of the kidneys, ureters, and bladder can be obtained on CT scans.

Types of imaging

Imaging method
Computed tomography (CT scan)

Reason for using it

Non-contrast CT:

- To diagnose urinary stones

Enhanced CT scans with intravenous contrast:

- To assess patients with blood in the urine
- To check for a mass in the kidney
- To assess the spread of prostate, bladder and testis cancer

If you review your CT scan images with your physician, it will appear as though your body has been converted to a loaf of bread and on the computer you can move through the body frontwards to backwards or top to bottom one slice at a time. Occasionally 3-dimensional reconstructions can be completed using special software which may better demonstrate certain types of the anatomy to your physician. CT scans have a wide variety of use within urology and can be completed without intravenous contrast, a non-contrast CT, or with intravenous contrast, contrast-enhanced CT.

CT scans are associated with more radiation than plain radiographs and as such should be used judiciously. For example, if a stone is visible with a KUB, it is better to follow the progress of the stone and manage it with plain radiographs than with CT scanning to avoid unnecessary exposure to radiation.

CT scans may be used in follow-up after treatment of urologic cancers. For example, if you are treated for kidney, bladder or testis cancer, you could expect to have a number of CT scans per year based on the follow-up protocol for your cancer. You should discuss other ways to manage your cancer (other than with a CT scan) with your doctor so that your exposure to radiation is as small as possible.

Ultrasonography

Ultrasonography or ultrasound is a relatively inexpensive and almost universally available. This technique uses the interaction of sound waves, produced by a transducer which is placed in contact with the body, with tissues in the human body to produce images. This type of investigation is often performed with an ultrasound technician with or without a radiologist or urologist.

The technician places a gel on the skin which allows the sound waves to be transmitted into the body. Without the gel, the sound waves are dispersed within air between the transducer and the skin and images cannot be obtained.

Ultrasound does not expose you to any radiation. Minimal heating of the tissue in the region of the ultrasound may occur and in addition you may feel pressure if the ultrasonographer needs to push harder on the skin to get a better image.

While undergoing ultrasound of the kidney, the ultrasonographer may be directed to look at other structures within the abdomen, including urologic organs as well as the urinary bladder. The urinary bladder may also be assessed by small portable hand-held ultrasounds to make sure that the bladder is emptying properly. This is common in men with enlarged prostate and hospitalized patients with problems emptying the bladder after surgery.

Types of imaging

Imaging method
Ultrasonography

Reason for using it

- To assess the kidneys, bladder emptying, prostate, testicles and penis
- To check for any hydronephrosis or blockage of the kidney
- To determine whether masses in the kidney discovered on CT scan are solid, which are more concerning for cancer, or cystic, fluid-filled structures which are less concerning for cancer
- Used after treatment of kidney stones, to ensure that the kidney is draining properly and to follow solid or cystic lesions in the kidney

Imaging method
Transrectal ultrasound (placing the ultrasound probe within the rectum through the anus)

Reason for using it

In men:

- To estimate prostate size
- To guide biopsy of the prostate to diagnosis prostate cancer
- To assess the penis to see if there is any scarring or plaque present (common in cases of Peyronie's disease, where the penis is curved on erection and there is pain)
- To rule out testicular torsion, a condition in which the testicle loses its blood supply due to twisting of the spermatic cord
- To assess erectile function

In women:

- To better assess pelvic organs including the cervix, uterus and ovaries

In both men and women:

- To assess blood flow to the kidney and drainage of urine from the kidney following renal transplantation

Magnetic Resonance Imaging (MRI)

MRI scanning produces similar cross sectional images to those obtained with CT scans. In certain cases, MRI provides an advantage in assessing soft tissue in the body over CT scanning. It does not always require the use of contrast, and can be used in patients who cannot receive radiographic contrast required for CT scanning.

MRI scans can be obtained with contrast as well; however, the contrast utilized is different than that for CT scans.

With MRI scanning, you need to lay still on a table which is moved into a large magnet. The magnet is very close to you; if you have anxiety or claustrophobia, you may need to be sedated. There is no radiation exposure during an MRI. MRI scanning obtains pictures in a complex manner by the alignment and realignment of water molecules in the body when the magnet is turned on and off.

MRI is not as available as ultrasound. The wait list to receive an MRI in certain regions can be long. Remember that in many cases, MRI images are not necessarily better than CT images and may not be needed in most cases.

Some MRI scans require the administration of contrast which is gadolinium-based. This is different than the contrast used and plain radiography or CT scanning. Care must be taken when giving gadolinium-based contrast to patients with poor kidney function due to the risk of NSF (discussed in the section on risks of imaging).

Types of imaging

Imaging method

Magnetic resonance imaging (MRI)

Reason for using it

- To assess solid and cystic masses in the kidney
- To see if there is any spread of kidney tumours into the vena cava
  - The vena cava is a large vein which runs along the back of the body and receives drainage of blood from both kidneys. Sometimes kidney tumours invade this vein – doctors need to know this before they surgically remove your kidney. If your CT scan showed a possibility that your vena cava is affected, you may get an MRI.
- To monitor patient's with small renal masses
- To assess the adrenal glands and the prostate.
  - Adrenal glands, located above the kidneys, are small glands which produce hormones. Certain tumours involving the adrenal glands are well seen on MRI scans.
- With a component placed in the rectum, to diagnose prostate cancer

Nuclear scintigraphy

Nuclear scintigraphy or nuclear scanning involves injecting radioactive substance intravenously. After the injection, you must lay still under a special camera which detects the radioactive substance.

The most common type of blockage this test is used to assess is called ureteropelvic junction, or UPJ, obstruction. In this condition there is a blockage where the drainage system of the kidney meets the ureter, the tube through which urine drained from the kidney to the bladder. A nuclear scan may be used to diagnosis this condition and also to follow progress after treatment. In addition, nuclear renal scan may be used to assess function of transplanted kidneys.

Bone scans are special nuclear scans to check for any tumour spread to the bone, most commonly in prostate cancer. It should be noted that not all bone scans that are positive, meaning showing an abnormality, are cancer. Other conditions such as a trauma, arthritis, surgery and infection can show abnormalities on bone scan.

Types of imaging

Imaging method
Nuclear scintigraphy

Reason for using it

- In combination with a diuretic (a medication to increase your urine output), to determine if there is any obstruction or blockage of the urinary tract
- To assess urologic cancers

Imaging method
PET scanning, or positron emission tomography
(an advanced nuclear test in which a radioactive sugar molecule is injected intravenously; any concentration of this sugar may be a sign of cancer)

Reason for using it

- To assess testis cancer

Putting it all in perspective

Advances in medical imaging are responsible for improved care and survival of patients with a variety of urologic diseases.

The risks associated with imaging, exposure to radiation or contrast agents, must always be balanced with the harms associated with not identifying a diagnosis because no imaging was completed. This may exposure you to as much or often more harm associated with the relatively low risk of significant complications related to medical imaging.

New contrast agents and new imaging acquisition and processing are constantly changing. The result of this is that many risks are likely to decrease in the future. Try to limit your risk to radiation as much as possible.

If you have any questions about your risks or questions about imaging alternatives, discuss this with your urologist before you undergo the test.